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Research Article

LANGUAGE ACQUISITION IS HORMONALLY-BASED: A PLAUSIBLE LOOK

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ABSTRACT
Debate in the neurolinguistics ranges across a slew of issues, but in one thing they are not well investigated; that is, which path do males or females pursue in language acquisition? But what makes our mind obsessed is that when males and females get matured, they are not, but can be affected by hormonal influences. The present paper is an attempt to have a review on the impact of testosterone on language acquisition. In a sense, indeed, reduced cognitive ability can be related to the low levels of testosterone. Thus, to the present writers, the development of cognitive ability, in general, and language acquisition, in particular, is hormonally-based.

Keywords: *Estrogen, Hormone, Language Development, Progesterone, Testosterone*

INTRODUCTION
Differences in the neurobiology of females and males have not been conclusively identified (Kaiser, Haller, Schmitz, and Nitsch, 2009). Although sex difference is respected as an important factor in the neurocognition of language (Hartshorne and Ullman, 2006), it has been virtually ignored in the studies of language acquisition. Halpern (2000) asserts that in language acquisition, sex differences are not so evident. According to Hartshorne and Ullman (2006), sex differences may not have been demonstrated for two reasons: such studies generally do not place emphasis "on the subcomponents of language, and thus could have missed differences limited to one of them. Second, most studies have been exploratory rather than hypothesis-driven, and so might not have probed for specific sex differences predicted by particular theoretical perspectives". Henceforth, the study of sex has been virtually stuck to the margin in relation to learning, representation, processing, and neural bases of language (Melville, 2006).
The earlier findings of neurolinguists are highly inspired by the popular notion among researchers that the biology of females and males, per se, is unique and individual. The notion of *uniqueness* is a real dimension of *personal* being. Uniqueness is widely revealed when males and females respond differently to different phenomena since they use their brains differently.
However, researchers have long agreed that females are better at language learning than males, but until now they have little provided a biological basis to take into consideration their differences. According to a study conducted at Northwestern University in 2008, females and males process language differently. The study indicated that females' brain, when learning, shows greater activity in the areas used for language encoding (Merritt, 2014). Undeniably, the battle of the sexes has become a heated topic for researchers. The current work is an attempt to revitalize the biology of SLA.

Review of the Related Literature
That the two sexes appear to be pursuing the same route in language acquisition is apparent, but, in fact, they are using two different neurocognitive brain processes (Ullman, 2005). What has to be brought into consideration is that generally, there are several factors—both nurture- and nature-based—getting involved in the dynamicity of brain functioning. Whether these factors determine the route of learning in L2 context is a matter of issue that needs to be investigated. Not standing away from the nurture-based view of language acquisition, several scholars (Hines, 1982; Notman and Nadelson, 1991) insist on the study of hormones and brain to the psychology of language learning. Indeed, the nature–nurture debate is

highly contentious in the psychology of sex, and thus contemporary researchers only sometimes prefer to integrate the two causal influences (Eagly and Wood, 2013). However, no one has dared to claim that language question is hundred percent nature-based or nurture-based. As to Hinton, Miyamoto, and Della-Cjiesa (2008), there appears to be a dramatic sporting event between nature and nurture. Henceforth, there is a false dichotomy that many young educators suffer from: genetics and experience (Maftoon *et al.*, 2014). Furthermore, one reason for the very dichotomy can be that most of the theories in SLA are "not in fact really theories, but rather either descriptive, non-explanatory frameworks for L2 researchers on the one hand, or else metaphors for organizing one's thoughts on the other" (Gregg, 1993).

Hormones and Brain: A Brief Look

Hormones are chemical substances made by endocrine glands and secreted into the blood stream. Interest in the role of hormones in brain development is not a new issue, but less has been paid regarding the role of hormone in language acquisition. "Hormones can determine what the brain is interested in doing" (Brizendine, 2006). Comparing the role of hormones in males and females, Brizendine puts forth:

…the female brain is so deeply affected by hormones that their influence can be said to create a woman's reality. They can shape a woman's values and desires, and tell her, day to day, what's important. Their presence is felt at every stage of life, right from birth. Each hormone state—girlhood, the adolescent years, the dating years, motherhood, and menopause—acts as fertilizer for different neurological connections that are responsible for new thoughts, emotions, and interests.

Besides, "the effects of sex hormones on brain organization occur so early in life that from the start the environment is acting on differently wired brains in boys and girls (Kimura, 1999). Kimura, further, adds cognitive patterns may remain sensitive to hormonal fluctuations throughout life.

Before delving into the main thesis of the paper concerned with the impact of hormones, in general, and testosterone, in particular, on language development, let us first get a bit familiar with sex hormones. Generally, as Davison (2012) outlines, there are three types of sex hormones: progestagens, androgens, and estrogens. Progestagens are respected as a class of female hormones as mostly produced by the ovaries. Progesterone plays a critical role in both men's and women's brain. This type of hormone is responsible for the myelination of the brain cells that contributes to the quick communication. Androgens are typically considered as male hormones that play a more significant role in the development of male sex organs than female sex organs. Testosterone—the primary androgen—does exist in men more than women. As Davison asserts, the presence of testosterone is also critical to females because it converts progesterone to estrogen, and lack of it leads to deficit in estrogen and is blamed for bone loss, fatigue, low blood pressure (Davis, McCloud, Strauss, and Burger, 2003 cited in Davison, 2012). Further, testosterone is highly implicated in the neural circuitry involved in self regulation and control (Eagly and Wood, 2013). The third class of hormone—estrogen—is more significant in regulating the female reproductive cycle, but they are also essential to the male brain. Estrogens stimulate the production of nerve growth in both males and females.

In other words, "efficient regulation of estrogens is fundamental to a healthy and properly functioning nervous system for both genders" (Davison, 2012). O'Brien (2008), in the same vein, asserts that estrogen and testosterone, and even progesterone influence brain development even during puberty, although the process by which the brain and hormones interact is very complex. In sum, it is due to these hormones that females' brains are programmed to keep social harmony, while males' brains are wired to keep competing.

There is not much space in the paper to deal with the three types of hormones. Thus, in the present article, we have provided an explanatory set of data regarding the impact of testosterone on language development.

In disfavor with hypothesis-driven type of research which seems to be unethical to some extent, the present researchers do believe obtaining any coherent message from sex psychology entails the integration of the findings of diverse collections of research on gender. Importantly, conceiving the importance of hormones, the present writers make an endeavor towards the very thesis that language acquisition is hormonally-based.

Brain and Testosterone

That we use only 10% of our brain is fundamentally untrue (Beyerstein, 1999). In this regard, Davison (2012) holds "neuroscience is inundated with myths and of particular concern are those that negatively influence views about cognitive and behavioral differences between genders" (p. 1). Nonetheless, no one denies that **t**he brain is a complex organ. Made up of a network of neurons, the brain receives, processes, and stores information. Experiments carried out on males and females indicate that cerebral morphological differences begin in the womb, and are relatively permanent after the fetus is 26 weeks old (Achiron, Lipitz, and Achiron, 2001, cited in Magon, 2009). In other words, according to several scholars (e.g., Gurian and Stevens, 2004), females' and males' brains do not appear to be affected by hormonal influences as they mature. Incompatible with such findings, Beauchet (2006) does insist that unbalanced level of hormones should exert a negative effect on both females and males.

Put differently, testosterone levels are in line with males' age. As a man gets older, the level of testosterone declines (Leifke *et al.,* 2000, cited in Beauchet, 2006). The more decrease in testosterone is observed in males, the more cognitive dysfunction is resulted (Beauchet, 2006). Henceforth, the mediocrity in the level of testosterone is highly suggested. Indeed, the abnormal level of testosterone can also change the anatomy of the brain. In fact, the left brain hemisphere development gets delayed and normal brain asymmetry fails to develop (Geschwind and Behan, 1982, cited in Tallal, 1991). In this regard, Whitehouse *et al.,* (2012) assert "higher concentrations of testosterone increased the risk of language delay in males, and reduced the risk in females". Put differently, high level of testosterone in males at all points in development is not an indicator of skills at which a male excels (Brizendine, 2006).

In the same line, cognitive abilities including memory, attention, and language ability decline as people age (Liverman and Blazer, 2004, cited in Beauchet, 2006). Henceforth, Beauchet does believe that by injection of balanced levels of testosterone, brains cognitive ability will be improved. In this regard, Azad, Pitale, Barnes, and Friedmanl (2003) reported that after 3-5 weeks, testosterone substitution in seven men suffering from Hypogonadism, cerebral perfusion had been increased in the midbrain and the superior frontal gyrus, and after 12–14 weeks, increased perfusion was still observed in the midbrain as well as the midcingulate gyrus.

Seen from this stance, there is unanimity among scholars (e.g., Alexander, 2014; Beauchet, 2006) that testosterone has an impact on infants' language development, but there is less paid to the postnatal impact of the very hormone. Recent attempts made by Alexander (2014) indicate "postnatal testosterone concentrations influence male infant preferences for larger social groups and temperament characteristics associated with the later development of aggression". Moreover, Alexander asserts that postnatal testosterone may encourage increased activity levels, and thereby influence the development of male-typical social structures.

In a nutshell, no one denies that the impact of testosterone as infants get matured gets less critical in language development; however, the unbalanced level of it at the early infancy will surely result in biological unpreparedness including delay in language development. Further, as Alexander concluded higher testosterone concentrations will result in the deficit in communication and social interactions that characterized autism that is more common among males.

Generally, there are several hypotheses regarding the influence of testosterone on males' brain in comparison with females'. Pfannkuche, *et al.,* (2009) outlines four hypotheses in this regard. The first hypothesis was raised by Witelson and Nowakwski (1991) who maintain that testosterone in males would decrease the information exchange between the two hemispheres since axonal pruning in the corpus callosum is stimulated. The second hypothesis is proposed by Geschwind and Galaburda (1985) who claim that the increase in testosterone inhibits the growth of the left hemisphere. Henceforth, due to the high exposure to testosterone, such functions as right handedness dominated by the left hemispheres will become less lateralized. The third hypothesis is concerned with this postulation that the sex differences in lateralization are due to being part of sexual differentiation which is under the influence of testosterone which leads to the masculinity and the degree of lateralization. Henceforth, as the amount of testosterone in males is high, the strength of language lateralization is predicted. The four and somehow the most

recent hypothesis is put by Lauter (2007). Lauter's hypothesis manipulates that prenatal exposure to testosterone would induce individual variation in pruning of connectivity throughout the brain and both sexes. In other words, exposure to low levels of testosterone contributes to the connectivity and full development of the left and right hemispheres. The connectivity leads to the full capacity of the left hemisphere; henceforth, resulting in strong right-handedness. Moderate exposure influences the left hemisphere, resulting in more ambidexterity and left-handedness. Finally, a higher level of exposure to testosterone would also affect the right hemisphere, and in cases of severe overall pruning it would inhibit the supposed coordinating and nurturing of the left brain function of the right hemisphere, releasing growth on the left side. This would lead to strong right-handedness again, and so the effect of prenatal testosterone exposure is not linear (Pfannkuche, *et al.*, 2009).

Female Brain and Male Brain Function Differently

The differences in the female and male brain can be investigated from two dimensions. Structurally, what makes the females' brain distinct from males' ones is that the density of white and grey matters in females' corpus callosum makes the process of language acquisition easier and faster than males (Gur, *et al.*, 1999). Gur *et al.*, contend that the female brain has a higher percentage of grey matter in the left hemisphere which aids language skills. From the other side, the functional brain differences among males and females are worth garnering a lot of attention. As Gurrian and Stevens (2004, cited in Magon, 2009) maintain physiologically, female brains have been found to metabolize glucose at higher rates and to experience greater blood flow in comparison to males.

Ullman (2005) maintains that males and females may process words differently because of different levels of the hormone estrogen, which is much higher in females and affects brain processing. Along the same line, it can be hypothesized that the amount of testosterone affects the procedural memory of males. Ullman, in this regard, puts forth that probably because of the high amount of estrogen in females, they were better at storing vocabulary and idiomatic expressions, whereas males perform faster on catching grammar rules. In the study reported by Hartshorne and Ullman (2006), the result, similarly, indicated that females make use of their declarative memory in comparison with males who use their procedural memory in using regular and irregular past-tense forms of verbs. In other words, males and females may tend to process various skills differently from one another (Hartshorne and Ullman, 2006; Ullman, 2005). Because irregular tenses like "held" are memorized in declarative memory, Hartshone and Ullman (2006) suppose that girls would make less mistakes like "holded", as they are due to the application of the "-ed" rule of regular verbs. Nevertheless, the results were exactly the opposite: Girls used "holded" far more than boys. In fact, words liked "holded" had many rhyming verbs with regular past-tense forms, like "folded" and "molded". They concluded that the girls were using their declarative memory to stick the regular past tense forms and then applied them to rhyming irregular verbs. For males, in contrast, there was no association between the number of rhyming regular past-tense verbs and the verbs that were used incorrectly: they were using their procedural memory that contained the rule: add "-ed" to form the past tense of verbs.

Language Acquisition Is Biologic

The history of the brain shows that not all theories were correct and with the advancement of technology, many of the theories that we now believe to be true may in fact not be so accurate in the future (Bergen and Coscia, 2001, cited in Wasswerman, 2007). It is not legitimate to claim that language acquisition is heritable, but what is clear is that there are biological factors that play a pivotal role in the development of language. The current paper does not tend to downgrade the findings of nurture-based theories; however, it is of the thought that language acquisition is hormonally-based. Due to the unbalanced level of testosterone, males' cognitive ability will be distorted; thus, by temporary substitution of the given hormones the brain cognitive ability can be rehabilitated. Although females and males presumably pursue the same path (Ullman, 2005), now it is time to investigate which factors do affect the route of language acquisition. Long has been reported regarding the rate of language acquisition and development, but less has been paid to the route of language acquisition. To the present writers, knowing how testosterone will affect female and male brain, for instance; and which parts of the brain in females and males will be

affected will certainly pave the path towards grasping a plausible understanding of language acquisition. In fact, studying hormones, in general, and testosterone, in particular, uncovers many mysteries regarding the route of language acquisition. For example, it can plausibly be put forth that since men's blood has a higher level of testosterone, they are willing to communicate much more aggressively than females (Karafyllis and Ulshöfer, 2008). Furthermore, "too much testosterone in the womb was also thought to influence the development of left-handedness and dyslexia" (Karafyllis, 2008, p.243), for instance.

CONCLUSION

So much has been reported that females have an advantage over males regarding different kinds of verbal ability. That women's speech, for instance, is more fluid than men's is not a recent issue. However, having an etiological look towards such findings is worthwhile. More specifically, the males' higher levels of testosterone, which delays the development of the left hemisphere, might partly explain these differences, though other factors may also come into play. Along the same vein, several scholars (e.g., Friederici *et al.*, 2008) maintain that the observed differences between males and females can be investigated by the hormone testosterone, which negatively affect the phonological discrimination abilities in one month olds. In fact, as Friederici *et al.*, concluded, girls "generally low on testosterone demonstrated a clear phonological discrimination effect with a bilateral distribution…. [boys, in contrast,] with high testosterone showed no discrimination effect, whereas males with low testosterone displayed a discrimination effect, which was clearly left-lateralized" (p. 283). Parallel to the same argument, Beauchet (2006) maintains that reduced cognitive ability is related to the low levels of testosterone; henceforth, to him, "testosterone substitution may improve some aspects of cognitive ability.

REFERENCES

Alexander GM (2014). Postnatal testosterone concentrations and male social development. *Frontier in Endocrinology* **5**(15). DOI:10.3389/fendo.2014.00015

Azad N, Pitale S, Barnes WE and Friedman N (2003). Testosterone treatment enhances regional brain perfusion in hypogonadal men. *Journal of Clinical Endocrinology and Metabolism* **88** 3064–3068.

Beauchet O (2006). Testosterone and cognitive function: current clinical evidence of a relationship. *European Journal of Endocrinology* **155** 773-781.

Beyerstein B (1999). *Mind Myths: Exploring Popular Assumptions about the Mind and Brain* (West Sussex, UK: Wiley).

Bishop DVM (2006). What causes specific language impairment in children? Available: file:///C:/Users/ farakavosh/ Desktop/gene%20for %20language.htm, 2014.

Brizendine L (2006). *Female Brain* (Broadway Books) New York.

Davison RC (2012). Critically thinking about the brain and gendsert differences. In: *Apply Research to Practice (ARP),* edited by Bogue B & Cady E, Available: http://www.engr. psu.edu/AWE/AR PResources.aspx, 2014.

Eagly AH and Wood W (2013). The nature-nurture debates: 25 years of challenges in understanding the psychology of gender. *Perspective on Psychological Scienc*e **8**(3) 340-357. DOI: 10.1177/ 174 569 1613484767

Friederici AD, Pannekamp A, Partsch CJ, Ulmen U, Oehler K, Schmutzler R and Hesse V (2008). Sex hormone testosterone affects language organization in the infant brain. *Neuroreport* **19** 283–286.

Geschwind N and Galaburda AM (1985). Cerebral lateralization: biological mechanisms, associations, and pathology.3. A hypothesis and a program for research. *Archives of Neurology-Chicago* **42** 634–654.

Gregg KR (1993). Taking explanation seriously, or let a couple of flowers bloom. *Applied Linguistics* **14**(3) 276-294.

Gur RC, Alsop D, Glahn D, Petty R, Swanson GL, Maldjian JA, Turetsky BI, Detre JA, Gee J and Gur RE (2000). A fMRI study of sex differences in regional activation to a verbal and a spatial task. *Brain and Language* **74**(2) 157–170.

Gur RC, Turetsky BI, Matsui M, Yan M, Bilker W, Hughett P and Gur RE (1999). Sex differences in brain gray and white matter in healthy young adults: Correlations with cognitive performance. *The Journal of Neuro*science **19** 4065-4072.

Gurian M and Stevens K (2004). With boys and girls in mind. *Educational Leadership* **62**(3) 21-26.

Halpern DF (2000). *Sex Differences in Cognitive Abilities,* 3rd edition (Lawrence Erlbaum Associates) New Jersey.

Hartshorne JK and Ullman MT (2006). Why girls say 'holded' more than boys. *Developmental Science* **9**(1) 21-32.

Hines M (1982). Prenatal gonadal hormones and sex differences in human behavior. *Psychological Bulletin* **92** 56– 80. DOI:10.1037/0033-2909.92.1.56

Hinton C, Miyamoto K and Della-Chiesa B (2008). Brain research, learning and emotions: Implication for education research, policy and practice. *European Journal of Education* **43**(1) 87-103.

Kaiser A, Haller S, Schmitz S and Nitsch C (2009). On sex/gender related similarities and differences in fMRI language research. *Brain Research Reviews* **61**(2) 49–59. DOI:10. 1016 /j. brainresrev.2009.03.005

Karafyllis NC (2008). Oneself as another? Autism and emotional intelligence as pop science, and the establishment of "essential" differences". In: *Sexualized Brains: Scientific Modeling of Emotional Intelligence from a Cultural Perspective,* edited by Karafyllis C and Ulshöfer G (MIT Press: Cambridge) 237-315.

Karafyllis NC and Ulshöfer G (2008). Introduction: Intelligent emotions and sexualized brains—discourses, scientific models, and their interdependencies. In: *Sexualized Brains: Scientific Modeling of Emotional Intelligence from a Cultural Perspective,* edited by Karafyllis C and Ulshöfer G (MIT Press: Cambridge) 1-49.

Kimura D (1999). Sex Differences in the Brain. Available: www2.nau.edu/~bio372-c/.../sexdif1.

Lauter JL *(*2007). The EPIC model of functional asymmetries: implications for research on laterality in the auditory and other systems. *Frontiers in Bioscience* **12** 3734–3756. DOI:10.2741/2348

Leifke E, Gorenoi V, Wichers C, Von Zur Muhlen A, Von Buren E and Brabant G (2000). Age-related changes of serum sex hormones, insulin like growth factor-1 and sex- hormone binding globulin levels in men: cross-sectional data from a healthy male cohort. *Clinical Endocrinology* **53** 689–695.

Maftoon P, Shakouri N and Nazari O (2014). Limbic system and second language acquisition. *Biological Forum-International Journal* **6**(2) 398-404.

Magon AJ (2009). Gender, the brain and education: Do boys and girls learn differently? Available: https://dspace.library.uvic.ca:8080/...magon _project

Melville K (2006). Big gender differences in language learning. Available: http:// www.sciencea gogo.com /news /20061029224800data_trunc_sys.shtml.

Merritt A (2014). Are women really better at learning languages? Available: http://www. telegraph.co.uk/education/educationopinion/10567876/Are-women-really-better-at-learning-anguages.html

Notman MT and Nadelson CC (1991). A review of gender differences in brain and behavior. In: *Issues in Psychiatry. Women and Men: New Perspectives on? Gender Differences,* edited by Notman MT and Nadelson CC (American Psychiatric Association, Arlington, VA) 23-34.

O'Brien G (2008). Understanding ourselves: Gender differences in the brain. Available: http:// www.c olumbiaconsult.com/ pubs/v52_fall07.html, 2014.

Pfannkuche KA, Bouma A and Groothuis TGG (2009). Does testosterone affect lateralization of brain and behaviour? A meta-analysis in humans and other animal species. *Philosophical Transactions of the Royal Society B* **364** 929–942. DOI:10.1098/rstb.2008.0282

Tallal P (1991). Hormonal influences in developmental learning disabilities. *Psychoneuroendocinology* **16** (1-3) 203-211.

Ullman MT (2005). A cognitive neuroscience perspective on second language acquisition: The Declarative/ Procedural Model. In: *Mind and Context in Adult Second Language Acquisition,* edited by Sanz C (Georgetown University Press, Washington DC) 141–178.

Wasserman LH (2007). The correlation between brain development, language acquisition, and cognition. *Early Children Education Journal* **34**(6) 415-418. DOI:10.1007/s10643-007-0155-x

Whitehouse AJO, Mattes E, Maybery MT, Sawyer MG, Jacoby P, Keelan JA and Hichey M (2012). Sex-specific associations between umbilical cord blood testestrone levels and language delay in early childhood. *Journal of Child Psychology and Psychiatry* 1-9. DOI:10.1111/j.1469-7610.2011.02523.x

Witelson SF and Nowakowski RS (1991). Left out axons make men right: a hypothesis for the origin of handedness and functional asymmetry. *Neuropsychologia* **29** 327–333. DOI:10.1016/0028-393 2 (91) 90046.

Woolley CS and Schwartzkroin PA (1998). Hormonal effects on the brain. *Epilepsia* **39**(8) 2–8.